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(54) Title: LAMINATED STRUCTURES WITH SUPERIOR IMPACT RESISTANCE AND PROCESS FOR MAKING SAME

(57) Abstract: The present invention is a laminate article comprising at least three layers of plasticized polyvinylbutyral (PVB) sheet, wherein at least one layer of the laminate is a stiff PVB sheet and at least two layers are soft PVB sheets. A laminate article of the present invention is useful for providing increased protection from damages occurring to automobiles, buildings, and windows by virtue of exposure of same to, for example, hurricane force winds, impact from debris propelled by high-force winds, or by intentional impact against windows comprising the laminates of the present invention.

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TITLELAMINATED STRUCTURES WITH SUPERIOR IMPACT RESISTANCE
AND PROCESS FOR MAKING SAME

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This application claims the benefit of U.S.
Provisional Application No. 60/381,494, filed May 16,
2002.

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BACKGROUND OF THE INVENTION

Plasticized polyvinyl butyral sheet (PVB) is used
in the manufacture of laminate structures such as, for
example: windshields for vehicles including
automobiles, motorcycles, boats and airplanes; homes
and buildings; shelving in cabinets and display cases;
and other articles where structural strength and
laminate stability is desirable in a glass sheet. For
the purposes of the present application, laminate
stability refers to the ability of glass to remain
adhered to PVB and/or the ability of the laminate
layers to remain substantially together under harsh or
even extreme circumstances. In some special
applications, superior impact resistance and laminate
stability is required, or highly preferable. For
example, it can be preferred that laminates used in
homes and other buildings withstand the harsh
conditions prevalent in hurricanes, tornadoes, and/or
severe wind storms.

A wide variety of glass laminates formed with PVB
are known and described in U.S. Patent 4,297,262; U.S.
Patent 4,230,771; and, British Patent 828,381.
Typically, PVB is plasticized to have low stiffness and
deform readily upon impact -- which is an excellent
property for automotive windshields wherein human
impact is involved and passenger retention in a crash,
and hence, reduction in fatality is desired. However,
these are not the properties required for architectural

5 windows exposed to high stresses, nor for side windows
for automobiles and trucks that may be subjected to
criminal actions. The properties of low stiffness and
high elasticity limit performance when the laminate
must provide intrusion resistance after the glass of
the laminate has broken; for example, when a glass
laminate is subjected to high wind load, and/or impact
of flying debris as occurs in a hurricane, or where
there is repeated impact to a window by a criminal
attempting to break into a vehicle or structure.
10 Conventional PVB laminates such as windshields or
standard architectural laminated glass perform poorly
in tests designed to evaluate the performance of a
laminate under hurricane conditions, such as the Dade
County, FL hurricane window system test protocol
15 wherein there is a severe impact test followed by a
pressure cycling test conducted on the shattered
laminate.

Conventional PVB laminates can eventually fail in
a hurricane when they are subjected to pressure loading
and cycling. Failure can be due to either the large
deformation of the polymer interlayer which can cause
the laminate to pull out of the window frame, and/or
due to the action of shards of broken glass which
eventually cut into the PVB layer and allow air
25 pressure or other threat to permeate the structure that
the laminate is intended to protect. Conventional
laminates can also be penetrated more readily with
instruments used by a criminal attempting to gain entry
through the laminate. The use of layers of PVB that
30 are thicker than the standard laminate to gain more
stiffness and cut-through resistance is impractical due
to cost and the excessive thickness of the interlayer
required. Similarly, the use of stiffer PVB of
conventional thickness is difficult because the stiff
35

PVB is more difficult to process, and there is considerable manufacturing yield loss.

Stiffer glass laminates have been made using interlayers other than PVB, such as polyurethanes and thermoplastic copolymers and all of these, including PVB, in combination with polyester film and polycarbonate films. Bolton et al, U.S. Patent No. 4,663,228, for example, describes the use of an ionomer resin to form tough glass laminates.

There is an increased need for glass laminates for use as architectural windows that are resistant to the threats of wind storms and hurricanes, particularly in coastal areas. There is also a need for side windows for vehicles that are intrusion resistant. These glass laminates are required to have improved toughness and stability. They must also be easily fabricated, and have good optical properties - including color and clarity.

It is desirable to meet such needs with a PVB laminate that is tough, stable, and easily fabricated, and has good optical properties. These, and other objects of the invention will become apparent to the reader.

SUMMARY OF THE INVENTION

In one aspect, the present invention is a laminate article comprising at least two layers of soft plasticized polyvinylbutyral (PVB) sheet having a T_g in the range of from about 32°C to about 35°C and further comprising at least one layer of a stiff PVB interlayer sheet, wherein the stiff interlayer: (i) has a T_g of from about 35°C to about 60°C; (ii) is positioned between at least two layers of soft PVB; and, (iii) comprises a bleaching compound.

DETAILED DESCRIPTION OF THE INVENTION

In one embodiment, the present invention is a laminate article comprising at least three layers of plasticized polyvinylbutyral (PVB) sheet, wherein at least one layer of the laminate is a stiff PVB sheet and at least two layers are soft PVB sheets. A laminate article of the present invention is useful for providing increased protection from damages occurring to automobiles, buildings, and windows by virtue of exposure of same to, for example, hurricane force winds, impact from debris propelled by high winds, or by intentional impact against windows comprising the laminates of the present invention.

In the practice of the present invention, both soft and stiff PVB can be manufactured according to conventional processes known in the art of PVB manufacture. For example, a method of producing a soft PVB composition suitable for the practice of the present invention is described in U.S. Pat. No. 3,153,009, incorporated herein by reference. Plasticized PVB sheeting can be prepared by processes well known in the art. U.S. 4,276,351 describes a process for preparing plasticized PVB sheeting. U.S. Patent Number 4,696,971 also describes a process for manufacturing plasticized PVB sheeting. U.S. Patent 5,886,075 describes yet another process for manufacturing plasticized PVB sheeting.

A laminate of the present invention comprises at least two layers, or zones, of soft PVB. Soft PVB, as the term is used in the present invention, refers to PVB sheet that has a glass transition temperature (T_g) in the range of from about 32°C to about 42°C, as measured by Dynamic Mechanical Analysis ASTM D4065 (DMA), using the tangent delta (phase shift at 1 Hz) data as indicator.

In addition to at least two soft PVB sheets, a laminate of the present invention comprises at least one layer of a stiff PVB resin. A stiff layer of PVB, as the term is used herein, is PVB sheet having a T_g of greater than about 42°C to about 60°C, as measured by DMA ASTM D4065, using the tangent delta (phase shift at 1 Hz) data as indicator. Preferably, the T_g is from about 45°C to about 57°C, more preferably from about 47°C to about 57°C, most preferably from about 50°C to about 55°C.

The T_g of a PVB sheet can be dependent upon the concentration of plasticizer included in the composition. A soft PVB sheet of the present invention is plasticized with at least about 30 parts per hundred (pph) of a plasticizer. Preferably soft PVB of the present invention is plasticized with from about 30 to about 50 pph, based upon the total dry weight of the resin. The "dry weight" as used herein refers to the weight of the dry resin, that is, after water has been removed from the unplasticized PVB resin. More preferably the plasticizer is present in an amount of from about 30 to about 45 pph, and most preferably in an amount of from about 32 to about 45 pph. A stiff PVB sheet of the present invention preferably includes plasticizer in an amount of from about 5 to about 30 pph, more preferably the plasticizer content is from about 15 to about 30 pph. Even more preferably the plasticizer content is from about 18 to about 28 pph, and most preferably from about 18 to about 22 pph.

Plasticizers of the present invention can be chosen from any that are known or used conventionally in the manufacture of plasticized PVB sheeting compositions. For example, a plasticizer suitable for use herein can be a plasticizer or a mixture of plasticizers selected from the group consisting of: diesters obtained from the chemical reaction of

aliphatic diols with carboxylic acids, including diesters of polyether diols or polyether polyols; and, esters obtained from polyvalent carboxylic acids and aliphatic alcohols. For convenience, when describing the sheet compositions of the present invention, a mixture of plasticizers can be referred to herein as "plasticizer". That is, the singular form of the word "plasticizer" as used herein can represent the use of either one plasticizer or the use of a mixture of two or more plasticizers in a given sheet composition. The intended use will be apparent to a reader skilled in the art. Preferred plasticizers for use herein are diesters obtained by the reaction of triethylene glycol or tetraethylene glycol with aliphatic carboxylic acids having from 6 to 10 carbon atoms; and diesters obtained from the reaction of sebacic acid with aliphatic alcohols having from 1 to 18 carbon atoms. More preferably the plasticizer is either tetraethylene glycol di-n-heptanoate (4G7), triethylene glycol di-2-ethyl hexanoate (3GO) or dibutyl sebacate (DBS). Most preferably the plasticizer is 3GO.

Extrusion of a stiff PVB resin composition of the present invention can require high extrusion temperatures relative to the temperatures required to extrude soft PVB. For example, PVB resin plasticized with less than about 30 pph plasticizer can be extruded at a temperature of from about 225°C to about 245°C. Preferably the resin can be extruded at a temperature of from about 227°C to about 245°C. More preferably, the resin can be extruded at a temperature of from about 228 °C to about 242°C, and most preferably from about 230°C to about 240°C. Soft PVB can be extruded at a temperature of from about 175°C to about 225°C.

In a particularly preferred embodiment, PVB interlayers used in a laminate of the present invention has a YID color of less than 12. Due to higher

extrusion temperature necessary to process stiff PVB, which can result in undesirable color in the PVB sheet, the composition of the present invention includes at least one PVB bleaching compound. A PVB bleaching compound (bleaching compound) of the present invention is any compound that can reduce or eliminate color from a PVB resin relative to the color of an otherwise identical resin, treated using an identical or similar process, with the exception that a bleaching compound is not present. The mode of the bleaching action demonstrated by the bleaching compound is not critical to the present invention. For example, a bleaching compound useful in the practice of the present invention can be a compound that reacts directly with color-forming compounds (color bodies) present in a PVB resin composition, or a compound that is capable of yielding a compound that reacts directly with color-bodies. A bleaching compound can be a compound that can decompose in situ to yield decomposition products capable of reacting with color bodies present in a PVB resin composition. A bleaching compound in the practice of the present invention can be a compound that inhibits the formation of color bodies. Bleaching compounds of the present invention include, for example, inorganic bisulfites such as sodium or potassium bisulfite; organic bisulfites such as tetramethylammonium bisulfite; and compounds similar in structure or function. Bleaching compounds also include sulfosuccinates such as dialkyl sulfosuccinates. For example, the present invention can include sodium dioctyl sulfosuccinate (DOSS) as a bleaching compound.

A bleaching compound of the present invention can be included in any effective finite amount. An effective amount for the purposes of the present invention is any amount that reduces the color of a PVB

resin that includes a bleaching compound relative to the color of an identical or substantially similar PVB resin composition that does not include the bleaching compound. Alternatively, in the absence of comparative data, an effective amount is any amount that reduces the color of a PVB resin to less than 12 YID. Preferably the YID is less than about 10, more preferably less than about 8, and most preferably less than about 6. Color measurement of the resin can be done according to any conventional or standard practice.

A bleaching compound can be included in an amount of from about 0.01 to about 0.85 pph, based on the weight of polyvinyl alcohol (PVA) used in the preparation of PVB. Preferably, the bleaching compound is present in an amount of from about 0.05 to about 0.80 pph, more preferably in an amount of from about 0.10 to about 0.75 pph, and most preferably in an amount of from about 0.15 to about 0.70 pph. While color reduction in a PVB sheet is an important consideration, the amount of bleaching compound included will also be a function of the cost of production and the other properties that may be affected by including the additive.

The present invention includes a surfactant. A surfactant suitable for use herein can be any that is known to be useful in the art of polyvinylbutyral manufacture. For example, surfactants suitable for use herein include: sodium lauryl sulfate; alkali salts; ammonium lauryl sulfate; sodium dioctyl sulfosuccinate; ammonium perfluorocarboxylates having from 6 to 12 carbon atoms; sodium aryl sulfonates, adducts of chlorinated cyclopentadiene and maleic anhydride; partially neutralized polymethacrylic acid; alkylaryl sulfonates; sodium N-oleyl-N-methyl taurate; sodium alkylaryl polyether sulfonates; triethanolamine lauryl

sulfate; diethyl dicyclohexyl ammonium lauryl sulfate; sodium secondary-alkyl sulfates; sulfated fatty acid esters; sulfated aryl alcohols; and the like.

Preferable surfactants include sodium lauryl sulfate,
5 sodium dioctyl sulfocuccinate, sodium cocomethyl tauride, and decyl(sulfophenoxy)benzenesulfonic acid disodium salt.

The surfactant can be included in any effective amount for the particular set of process conditions
10 practiced. The surfactant can be included in an amount of from about 0.01 to about 0.85 pph by weight, based on the weight of PVA used to prepare PVB. Preferably the surfactant is included in an amount of from about 0.10 to about 0.80 pph. More preferably, the
15 surfactant is included in an amount of from about 0.15 to about 0.75 pph. Most preferably, the surfactant is included in an amount of from about 0.15 to about 0.70 pph.

The surfactant and the PVB bleaching compound can
20 be the same compound. The bleaching compound is optional only in the event that the surfactant can also perform the function of a bleaching compound. Otherwise the bleaching compound is considered to be essential in the practice of the present invention.
25 For example, DOSS can be used in the practice of the present invention as a surfactant. DOSS can also be a bleaching compound in the practice of the present invention. In one particularly preferred embodiment, DOSS can be included as both a surfactant and as a
30 bleaching compound. In this embodiment, the use of a bleaching compound other than DOSS is optional.

Antioxidants can be optionally included in a PVB resin composition of the present invention during sheet preparation to inhibit the oxidation of the PVB resin
35 and/or components. Preferred antioxidants are known conventionally and available commercially. Most

preferred are bis-phenolic antioxidants, which are surprisingly more suitable for preparing low color PVB sheeting, particularly when 3GO is used as plasticizer. Bis-phenolic antioxidants are available and can be
5 obtained commercially. Suitable bis-phenolic antioxidants include 2,2'-ethylidenebis(4,6-di-t-butylphenol); 4,4'-butylidenebis(2-t-butyl-5-methylphenol); 2,2'-isobutylidenebis(4,6-dimethylphenol); and 2,2'-methylenebis(6-t-butyl-4-
10 methylphenol), for example. Bis-phenolic antioxidants are commercially available under the tradename of ANOX™ 29, LOWINOX® 22M46, LOWINOX® 44B25, and LOWINOX® 22IB46, for example.

An antioxidant can be included in any effective
15 finite amount. Preferably, the antioxidant is included in an amount of from about 0.01 to about 0.6%, based on the total weight of the sheet. More preferably, the antioxidant is present in amount of from about 0.03 to about 0.3%, most preferably in an amount of from about
20 0.05 to about 0.25%.

Usual adjuvant compounds that are known conventionally to be useful in the PVB and do not adversely affect the impact performance of the laminates obtained therefrom can be included in a resin
25 composition of the present invention. Such additives include: antioxidants, colorants, light stabilizers, particularly UV light stabilizers/absorbers, such as Tinuvin® P; Tinuvin® 326, and Tinuvin® 123. UV light stabilizers can stabilize the PVB composition by
30 absorbing ultraviolet light and preventing unwanted effects by the UV light on the PVB. Adhesion control agents such as alkali and alkaline earth metal salts of carboxylic acids, alkaline earth metal salts of inorganic acids, or a combination of such salts can be
35 added. In the practice of the present invention it should be noted that in automotive windshields,

adhesion can be either too high or too low, and should be controlled so as to give maximum protection of the vehicle occupant from being ejected. In architectural and security laminates, it is desirable that adhesion
5 be maximized so that spontaneous delamination does not occur.

In still another embodiment, a laminate article can be obtained from a PVB sheet of the present invention. Procedures for preparing glass/PVB
10 laminates are well known in the art, and a skilled artisan would be able to construct a laminate from the presently claimed PVB sheet. A glass/PVB laminate article as claimed in the present invention can be obtained, for example, by bringing the surfaces of the
15 PVB and glass into contact, and then removing air from the laminate structure in an autoclave. The surface of the PVB can be roughened to facilitate removal of air from the laminate. Other procedures are known and used conventionally. While PVB/glass laminates are
20 described herein, PVB can be used as interlayer material for laminating to other materials such as polycarbonates, polyesters, and/or polyurethanes for example.

Laminates of the present invention contain
25 multiple layers of PVB having a total thickness of at least 0.75 mm. The thickness of the stiff PVB interlayer is preferably from about 20% to about 80% of the total thickness of the total interlayer thickness. More preferably the thickness of the stiff PVB
30 interlayer is from about 22% to about 70%, and most preferably from about 25% to about 60% of the total interlayer thickness.

In a particularly preferred embodiment, use of thin layers of stiff PVB in combination with layers of
35 soft PVB, arranged as described herein, surprisingly enhance the impact resistance of the laminate and avoid

the prohibitive manufacturing yield losses incurred using thicker layers of stiff PVB. A stiff PVB layer of the present invention has a thickness of from about 0.25 to about 10 mm, preferably the stiff PVB layer has a thickness in the range of from about 0.35 to about 8 mm. More preferably the thickness is in the range of from about 0.45 to about 6 mm, and most preferably from about 0.50 to about 4 mm.

EXAMPLES.

The following Examples and comparative examples are presented to further illustrate the present invention. The Examples are not intended to limit the scope of the invention in any manner, nor should they be used to define the claims or specification in any manner that is inconsistent with the invention as claimed and/or as described herein.

In the examples and comparative examples below, impact resistance is expressed as mean penetration energy. The mean penetration energy is determined by striking a 0.304 m x 0.305 m laminate clamped in a vertical frame with a 31.5-kg (70-lb) pendulum impactor fitted with a 76-mm diameter rounded protrusion (bull-nose) at room temperature ($21 \pm 2^{\circ}\text{C}$). The pendulum set up used in this work was similar to that described in British Standards Institute's AU 209, Part 4, except that the impactor was significantly heavier. Laminates of the same construction are sequentially hit with the impactor at release heights adjusted according to the Bruceton staircase method. If the bull-nose did not penetrate one laminate at a given impactor release height, the impactor release height for the next laminate in the set was increased by 76 mm (3 inches). Conversely, if the bull-nose penetrated a laminate at a given height, the impactor release height for the next laminate in the same set was decreased by 76 mm (3 inches). The mean penetration energy for each set of

laminates is the mean potential energy of the impactor required to penetrate the laminate 50% of the time. The mean penetration energy is the product of the mass of the impactor, gravitational acceleration, and the mean penetration height of the impactor. The mean penetration height of the impactor can be calculated using Bruceton staircase statistics as outlined in "Experimental Statistics" by Mary Gibbons Natrella, National Bureau of Standards Handbook 91, Washington, D.C., pages 10-22 to 10-23.

In all the Examples and Comparative Examples below, the PVB interlayers all contain between 50 and 100 ppm potassium as adhesion control additive. This additive was added as potassium formate to the polymer melt during sheet formation.

Comparative Example C1
PVB interlayers containing 35 parts 3GO plasticizer per 100 parts dry PVB resin (35-pph 3GO) totaling 2.54 mm in thickness were laminated between two pieces of 2.3-mm x 30.5 cm x 30.5 cm clear annealed float glass that had been washed and rinsed in demineralized water. The glass/PVB/glass assembly was de-aired by placing it in a rubber bag, sealing the bag and then applying vacuum to the bag. After 5 minutes of vacuum de-airing at ambient (about 23°C) temperature, the entire bag with the assembly and its contents were placed in a 120°C oven while maintaining vacuum. The rubber bag and its contents stayed in the oven for a total of 20 minutes, after which the bag was removed from the oven and the vacuum hose was disconnected. Eleven laminates made the same way were used for impact testing. The mean penetration energy of this set of laminates was 333 Joules.

Comparative Example C2

Eleven laminates with similar construction as those in Comparative Example C1 except that the PVB interlayers
5 contained 22-pph 3GO. The total interlayer thickness was 2.54 mm. The mean penetration energy was 383 Joules.

Comparative Example C3

10 Eleven laminates with similar construction as those in Comparative Example C1 except that the PVB interlayers contained 29-pph 3GO. The total interlayer thickness was 2.54 mm. The mean penetration energy was 330 Joules.

15

Comparative Example C4

Laminates were made with PVB interlayers stacked so that two 0.51-mm plies containing 20-pph 3GO sandwiched two plies of 0.76 mm containing 35-pph 3GO. The stack
20 of PVB sheets was laminated between two pieces of 2.3-mm glass as described in Comparative Example C1. The thickness of all the interlayers combined was 2.54 mm. The average plasticizer content of the interlayer was about 29 pph 3GO, about equivalent to that in
25 Comparative Example C3. Eleven such laminates were used for impact testing. The mean penetration energy was 325 Joules. This is also similar to that of the laminates in Comparative Example C3.

30 Example 1

Laminates were prepared as in Comparative Example C4 except that the PVB interlayers were stacked so that two plies of 0.76-mm 30-pph 3GO sheeting sandwiched two plies of 0.51-mm 20-pph 3GO sheeting. The thickness of
35 all the interlayers combined was 2.54 mm. The average plasticizer content of the interlayer was about 29 pph

3GO, about equivalent to that in Comparative Examples C3 and C4. Eleven laminates were impacted. The mean penetration energy was 455 Joules, a significant increase over the laminates in Comparative Examples C3
5 and C4 although the average plasticizer levels were equivalent.

WHAT IS CLAIMED IS:

1. A laminate article comprising at least two layers of soft plasticized polyvinylbutyral (PVB) sheet having a T_g in the range of from about 32°C to about 35°C and
5 further comprising at least one layer of a stiff PVB interlayer sheet, wherein the stiff interlayer: (i) has a T_g of from about 35°C to about 60°C; (ii) is positioned between at least two layers of soft PVB; and, (iii) comprises a bleaching compound.
- 10 2. The article of Claim 1 wherein the stiff PVB includes plasticizer in an amount of from about 5 pph to less than about 30 pph.
3. The article of Claim 2 wherein the plasticizer is present in an amount of from about 15 pph to less than
15 about 30 pph.
4. The article of Claim 3 wherein the plasticizer is present in an amount of from about 18 to about 25 pph.
5. The article of Claim 4 wherein the plasticizer is present in an amount of from about 18 to about 22 pph.
- 20 6. The article of Claim 2 wherein the plasticizer is a plasticizer or a mixture of plasticizers selected from the group consisting of: diesters obtained from the chemical reaction of aliphatic diols with carboxylic acids, including diesters of polyether diols
25 or polyether polyols; and, esters obtained from polyvalent carboxylic acids and aliphatic alcohols.
7. The article of Claim 6 wherein the plasticizer is selected from the group consisting of: diesters obtained by the reaction of triethylene glycol with
30 aliphatic carboxylic acids having from 6 to 10 carbon atoms; and esters obtained from the reaction of sebacic acid with aliphatic alcohols having from 1 to 18 carbon atoms.
8. The article of Claim 7 wherein the plasticizer is
35 triethylene glycol 2-ethylhexanoate.

9. The article of Claim 7 wherein the plasticizer is dibutyl sebacate.

10. The article of Claim 6 wherein the stiff PVB comprises a surfactant selected from the group
5 consisting of anionic surfactants, including: sodium lauryl sulfate, ammonium lauryl sulfate, sodium sulfosuccinate, ammonium perfluorocarboxylates having from 6 to 12 carbons, sodium aryl sulfonates, adducts of chlorinated cyclopentadiene and maleic anhydride,
10 partially neutralized polymethacrylic acid, alkylaryl sulfonates, sodium dialkylaryl polyether sulfonate, triethanolamine lauryl sulfate, diethyl cyclohexyl ammonium lauryl sulfate, sodium dialkyl sulfonates, sulfated fatty acid esters, sulfated aryl alcohols,
15 sodium dialkylsulfosuccinates, and the like.

11. The article of Claim 10 wherein the surfactant is selected from the group consisting of: sodium sulfosuccinate; and sodium dialkylsulfosuccinates.

12. The article of Claim 11 wherein the surfactant is
20 a sodium dialkylsulfosuccinates.

13. The article of Claim 12 wherein the surfactant is sodium dioctylsulfosuccinate (DOSS).

14. The article of Claim 13 wherein the bleaching compound is selected from the group consisting of:
25 sodium dialkylsulfosuccinates; sodium sulfosuccinates; organic bisulfites; inorganic bisulfites; and the like.

15 The article of Claim 14 wherein the bleaching compound is a sodium dialkylsulfosuccinate.

16. The article of Claim 15 wherein the bleaching
30 compound is sodium dioctylsulfosuccinate.

17. The article of Claim 16 wherein the PVB comprises an antioxidant.

18. The article of Claim 17 wherein the antioxidant is a substituted diphenolic compound.

19. The article of Claim 18 wherein the stiff PVB sheet has a thickness in the range of from about 0.1 mm to about 0.75 mm.

20. The article of Claim 19 wherein the stiff PVB sheet has a thickness in the range of from about 0.15 mm to about 0.72 mm.

21. The article of Claim 20 wherein the stiff PVB sheet has a thickness in the range of from about 0.20 mm to about 0.70 mm.

22. The article of Claim 21 wherein the stiff PVB sheet has a thickness in the range of from about 0.25 mm to about 0.68 mm.

INTERNATIONAL SEARCH REPORT

International Application No

PCT/US 03/16535

A. CLASSIFICATION OF SUBJECT MATTER

IPC 7 B32B17/10 B32B27/06

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

IPC 7 B32B

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

EPO-Internal, WPI Data, PAJ

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	WO 01 43963 A (SOLUTIA INC) 21 June 2001 (2001-06-21) page 2, line 14 - line 17; claims 7,26,27; example 15 page 4, line 21 -page 5, line 23 page 9, line 3 - line 22 page 10, line 22 -page 11, line 17	1-9,17, 19-22
X	US 5 227 241 A (NAOUMENKO YVES ET AL) 13 July 1993 (1993-07-13) column 1, line 5 - line 34 column 2, line 10 -column 4, line 59; figures 1,2; examples 1,2 --- -/--	1-7, 19-22

☒ Further documents are listed in the continuation of box C.☒ Patent family members are listed in annex.

* Special categories of cited documents:

- *A* document defining the general state of the art which is not considered to be of particular relevance
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- *P* document published prior to the international filing date but later than the priority date claimed

T later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

X document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

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G document member of the same patent family

Date of the actual completion of the international search

15 September 2003

Date of mailing of the international search report

25/09/2003

Name and mailing address of the ISA

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C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	US 5 573 842 A (GUTWEILER MATTHIAS) 12 November 1996 (1996-11-12) column 1, line 11 -column 2, line 21; claims 1,2 column 2, line 66 -column 3, line 10 -----	14,17
A	EP 0 102 502 A (HOECHST AG) 14 March 1984 (1984-03-14) page 1, line 12 -page 3, line 17 page 4, line 1 - line 16 -----	14,17
A	US 5 187 217 A (DEGEILH ROBERT ET AL) 16 February 1993 (1993-02-16) column 1, line 15 - line 58; claims 1,2 -----	10-13
A	US 4 696 971 A (DEGEILH ROBERT) 29 September 1987 (1987-09-29) cited in the application column 2, line 15 - line 53; examples 3-7 -----	10-13

INTERNATIONAL SEARCH REPORT

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WO 0143963	A	21-06-2001	AU 2261301 A	25-06-2001
			BR 0016319 A	20-08-2002
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VIII-2-1	<p>Declaration: Entitlement to apply for and be granted a patent</p> <p>Declaration as to the applicant's entitlement, as at the international filing date, to apply for and be granted a patent (Rules 4.17(ii) and 51bis.1(a)(ii)), in a case where the declaration under Rule 4.17(iv) is not appropriate:</p> <p>Name:</p>	<p>in relation to this international application</p> <p>E.I. DU PONT DE NEMOURS AND COMPANY is entitled to apply for and be granted a patent by virtue of the following:</p>
VIII-2-1 (iv)		<p>an assignment from WONG, Bert, C. to E.I. DU PONT DE NEMOURS AND COMPANY, dated 28 April 2003 (28.04.2003)</p>
VIII-2-1 (iv)		<p>an assignment from SMITH, C., Anthony to E.I. DU PONT DE NEMOURS AND COMPANY, dated 04 May 2003 (04.05.2003)</p>
VIII-2-1 (ix)	<p>This declaration is made for the purposes of:</p>	<p>all designations except the designation of the United States of America</p>

VIII-3-1	<p>Declaration: Entitlement to claim priority</p> <p>Declaration as to the applicant's entitlement, as at the international filing date, to claim the priority of the earlier application specified below, where the applicant is not the applicant who filed the earlier application or where the applicant's name has changed since the filing of the earlier application (Rules 4.17(iii) and 51bis.1(a)(iii)):</p> <p>Name:</p>	<p>in relation to this international application</p> <p>E.I. DU PONT DE NEMOURS AND COMPANY is entitled to claim priority of earlier application No. 60/381,494 by virtue of the following:</p>
VIII-3-1 (iv)		<p>an assignment from WONG, Bert, C. to E.I. DU PONT DE NEMOURS AND COMPANY, dated 28 April 2003 (28.04.2003)</p>
VIII-3-1 (iv)		<p>an assignment from SMITH, C., Anthony to E.I. DU PONT DE NEMOURS AND COMPANY, dated 04 May 2003 (04.05.2003)</p>
VIII-3-1 (ix)	<p>This declaration is made for the purposes of:</p>	<p>all designations</p>

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